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(54) **POWER LINE COMMUNICATIONS**

NACHRICHTENÜBERTRAGUNG ÜBER STARKSTROMLEITUNG

TELECOMMUNICATIONS SUR LIGNE DE PUISSANCE

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- **MORGAN, D.R. et al. 'Adaptive Interference Cancellation for Power Line Carrier Communication Systems', IEEE Transactions on Power Delivery, January 1991, Vol. 6, No. 1, pages 49-61,**

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Description

TECHNICAL FIELD

[0001] This invention relates to an apparatus and method for coupling signals onto a transmission line. It has particular application to coupling radio frequency (RF) signals onto an electricity distribution network which is used to transport telecommunications signals.

BACKGROUND TO THE INVENTION

[0002] It is known to transport telecommunications signals over an electricity distribution or power transmission network. Patent Application WO 94/09572 A1 (NORWEB) describes such a network. Delivering a telecommunications service in this manner is attractive as it overcomes one of the greatest costs in providing a new telecommunications network i.e. installing cabling to each subscriber. Existing electricity distribution cabling is used to carry the telecommunications signals.

[0003] Figure 1 shows an electricity distribution network which is adapted to carry telecommunications signals. Mains electricity enters the network from an 11kV transmission line 105 and is transformed by substation 100 into a 415V supply which is delivered over cable 120 to subscribers S. A base station BS couples telecommunications signals V_B, such as voice and data signals, at injection point 110 onto distribution cable 120. The telecommunications signals propagate over the cable on radio frequency carriers to transceiver units TRX at subscriber premises S.

[0004] One of the problems with transporting RF signals over the electricity distribution network is that of unwanted radiation of RF energy. The distribution network was not designed to carry RF signals.

[0005] Electricity distribution cables, such as cable 120, have a concentric structure. The inner section of the cable comprises groups of conductors which carry one or more of the three supply phases. This inner section is surrounded by an outer section which is coupled to earth. These cables have similar screening properties to coaxial cables, and conveniently this screening, coupled with the underground burial of the cables, is effective at the radio frequencies (RF) that are used for transporting telecommunications signals.

[0006] The internal wiring at subscribers' premises S is unscreened, and could potentially cause radiation problems. However, by filtering off the RF signals at the point where the electricity feeder cable becomes unscreened radiation of RF signals is minimised.

[0007] The other significant point where radiation can occur is at the substations 100 where electricity is transformed from 11kV to 415V. Substations have busbars which are typically mounted as a grid array on the substation wall. The busbars are shielded from view but frequently are electrically unscreened. This is because screening is considered unnecessary at the 50Hz mains frequency. At RF frequencies the busbar array functions as an antenna, radiating the RF signals which it receives via the distribution cables into the surrounding area. This is undesirable as it causes interference with equipment operating at these frequencies. This radiation may also violate regulations on Electromagnetic Compatibility (EMC).

[0008] One of the solutions to minimise radiation from the busbars is to screen the busbar array, or to screen the entire substation building. Some modern substations are equipped with metal casing around the busbars. However, the majority of substations are unscreened brick structures. It is undesirable to renovate all of these structures to improve their screening as it increases the cost of providing a telecommunications service over the network.

[0009] An alternative solution to the radiation problem is to restrict the power at which the RF signals are transmitted over the network, such that radiation occurring at substations falls below acceptable limits. This causes problems with subscribers' equipment, particularly to those subscribers furthest from the point at which RF signals are injected onto the network. Subscriber equipment needs an acceptable signal to interference ratio in order to detect the wanted RF signals. With considerable interference on the network, this demands a reasonably high transmit power.

[0010] The problem of radiation at the substation is compounded by the fact that RF signals are usually injected onto the distribution network adjacent to the substation. The reason for injecting at this point is because one base station can easily be coupled to each of a group of 415V cables (120, 130; 140 in figure 1) which all converge at the substation.

[0011] A paper entitled "Adaptive Interference Cancellation for Power Line Carrier Communication Systems" at pp. 49-61 of IEEE Transactions on Power Delivery, Vol 6, No 1, January 1991, addresses the problem of frequency reuse in a power line carrier system. A portion of a transmitted signal on a first line section which leaks through a line trap onto a second line section is cancelled by applying a cancelling signal to the second line section.

[0012] DE 2 523 090 describes a directional signal generator which controllably propagates in one direction along a line. This uses an attenuator network in series with the line.

SUMMARY OF THE INVENTION

[0013] The present invention seeks to minimise the above problem.

[0014] According to a first aspect of the present invention there is provided an apparatus for coupling signals to a line, the apparatus comprising:

- an input for receiving a wanted signal;
- a first means for coupling the wanted signal onto

the line at a first position;

- a cancelling means, coupled to the input, for deriving a cancelling signal from the wanted signal, the cancelling means being operable to phase-shift the wanted signal;
- a second means for coupling the cancelling signal onto the line at a second position, spaced from the first position; and wherein the apparatus is arranged so that the combination of the phase-shift and propagation delays experienced by the signals causes the wanted signal and the cancelling signal to destructively combine in a single direction of propagation along the line while enabling the wanted signal to propagate in the other direction along the line,

[0015] Preferably the cancelling means comprises a weight which is operable to scale the wanted signal in amplitude.

[0016] Preferably the spacing of the first and second couplers is substantially one quarter of a wavelength of the wanted signal. This maximises signal power in the wanted direction of propagation.

[0017] Preferably the apparatus also has a monitor for sensing the combination of the wanted and cancelling signals at a position on the line and feeding the sensed signal to a calculating means which controls the cancelling means. This allows a more effective cancellation.

[0018] The calculating means can perform an iterative technique in which perturbations are applied to the value of the weights and the sensed signal is monitored to determine the effect of the perturbations.

[0019] The calculating means may altematively perform an iterative technique in which the sensed signal is correlated with a portion of the wanted signal to determine updated weight values.

[0020] Preferably the apparatus is used to couple telecommunications signals to a power line such as a distribution line of an electricity distribution network for serving a plurality of subscribers.

[0021] In the situation where the telecommunications signals are coupled onto the electricity distribution network at a position between an unshielded part of the network and the subscribers, and the wanted and cancelling signals destructively combine in the direction of the unshielded part, this prevents unwanted radiation of signals from the unshielded part of the network.

[0022] A further application of controlling the direction of propagation of signals along the line is in allowing a particular frequency band which is in use on one line to be reused on the other lines. This has a particular use where an electricity distribution network has several distribution lines served by a common substation.

[0023] A further aspect of the invention provides a method of coupling signals to a line, the method comprising:

- receiving a wanted signal at an input;
- coupling the wanted signal onto the line at a first position;
- deriving, at a cancelling means, which is coupled to the input, a cancelling signal from the wanted signal, the cancelling means being operable to phase-shift the wanted signal;
- coupling the cancelling signal onto the line at a second position, spaced from the first position;
  and wherein the combination of the phase-shift and propagation delays experienced by the signals is arranged such that the wanted signal and the cancelling signal destructively combine in a single direction of propagation aiong the line while enabling propagation of the wanted signal along the line in the other direction.

[0024] A further aspect of the invention provides a method of coupling communications signals on to an electricity distribution network comprising a substation serving a plurality of distribution lines, the method comprising:

- coupling communications signals occupying a frequency band to one of the lines by coupling a wanted communications signal onto the line at a first position and coupling a cancelling signal onto a line at a second position, spaced from the first position such that the wanted communications signal and cancelling signal destructively combine in a direction of propagation towards the substation; and,
- reusing the frequency band for coupling different communications signals on to another one of the plurality of lines.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] For a better understanding of the invention, and to show by way of example how it may be carried into effect, embodiments will now be described with reference to the accompanying drawings, in which:

Figure 1 shcws an electricity distribution network which is adapted to transport telecommunications signals;
Figure 2 shows part of the network of figure 1 in more detail;
Figure 3 shows an arrangement to minimise radiation from an unscreened part of the network of figures 1 and 2;
Figure 4 describes the operation of the arrangement of figure 3;
Figure 5 shows the arrangement of figure 3 modified to include a monitoring circuit;
Figure 6 shows one form of calculating circuit for use in the arrangement of figure 5;
Figure 7 shows an alternative form of calculating circuit for use in the arrangement of figure 5;
Figure 8 shows an improvement to the arrangement of figure 5;

Figure 9 shows frequency reuse in an electricity distribution network.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0026] Referring again to figure 1, this shows an electricity distribution network which transports telecommunications signals. Figure 2 shows part of this network in more detail. Distribution cable 120 has three separate phase lines: Blue, Red and Yellow. Each of the phase lines are coupled to a respective busbar in substation 100. The output of basestation BS is coupled to a three-way splitter 210. Each of the three output lines is coupled, via a high-pass filter unit 200 to a respective phase line of cable 120. The mains filter serves to pass only signals in the RF bands which are used for transmission of telecommunications signals and to block the flow of mains electricity into the basestation. Telecommunications signals propagate along cable 120 in two directions; towards substation 100 and towards subscribers. Signal V_B is shown on the blue phase line. Telecommunications signals reaching substation 100 radiate RF energy 220.

[0027] Figure 3 shows the same section of the network as that shown in figure 2, but with modifications to minimise propagation of RF signals along cable 120 towards substation 100.

[0028] The output of basestation BS is split, as before, into a feed for each phase line. The feed for each phase line is split into two components; a main component V_{main}, and a cancelling component V_{aux}. V_{main} couples to cable 120 at position Y via a high-pass filter 200, as before. V_{aux} is coupled to cable 120 at a position X, spaced from position Y by a distance d. V_{aux} is weighted by a weight WB which phase-shifts the signal, and can also scale the signal in amplitude. V_{aux} and V_{main} are related in phase such that at point X, and in the direction towards substation 100, V_{aux} and V_{main} are offset in phase by 180° i.e. they are in anti-phase and destructively cancel. Therefore, the section of cable between point X and the busbars carries no RF signals, or RF signals at much reduced levels. Point X could be located at the busbars themselves.

[0029] Joints at points X and Y should be made using the same jointing technique, such that the RF coupling characteristics track in amplitude and phase. This gives optimum broadband cancelling performance.

[0030] By appropriate spacing of the main and auxiliary signal feeds, and appropriate phase-shifting at the weight, a further advantage can be gained. V_{main} and V_{aux} can be related in phase such that at point Y (and along the cable towards subscribers) they are in phase i.e. they constructively combine.

[0031] Typical transmission frequencies are the bands 2-6MHz and 10-14MHz. The optimum performance, with cancellation in the direction towards the substation and constructive interference in the direction towards the subscribers is achieved with the feed spacing $d=\frac{\lambda}{4}$ and a weighting phase-shift of 180°. The typical level at which the main signal can be coupled onto the line is 1Vrms. Such a high level may cause radiation problems in conventional systems.

[0032] The operation of the system will now be described further with reference to figure 4. Considering figure 4, the delays and phase shifts are arranged such that signals injected from the main feed and the auxiliary feed, and propagating towards the bus bars from point X, destructively interfere, but the signals propagating along cable 120 away from the bus bars do not destructively interfere. By arranging distance d to be approximately $d=\frac{\lambda}{4}$, the signals propagating in the direction towards the subscribers will be maximised. Cancellation at point X can be achieved for any distance d. At one extreme, it is possible to reduce the feed separation distance so that both feeds can be coupled to the cable within a distance which is small enough to fit within a section of cable exposed by the digging of a single hole.

[0033] Let us consider the main and auxiliary paths from the signal input to point X. When passing through the main path, signals undergo delay τ_1 in the feed cable, and delay τ_2 propagating through distance d to point X. The auxiliary path is arranged such that the feed delay to point X is equal to $\tau_1 + \tau_2$. By setting the weight θ_{weight} to give a 180° phase shift, it can be seen that ideally broadband cancellation between the signals propagating along the two paths to X can be achieved. In practice the weight value in phase and amplitude can be adjusted by an adaptive loop to compensate for mismatches between the feed paths. Alternatively, a fixed phase shift of 180° and zero attenuation can be set.

[0034] Now let us consider the main and auxiliary paths to point Y. Signals propagating along the main feed are delayed by τ_1. Signals propagating through the auxiliary path are delayed by $\tau_1 + \tau_2$ to point X, and by a further τ_2 when propagating through distance d to point Y, giving a total delay of $\tau_1 + 2\tau_2$. In addition, the signals propagating through the auxiliary feed are phase shifted by 180°. At point Y, therefore, the two components of the input signals are combined, one of which is delayed by τ_1, and a second component which is delayed by $\tau_1 + 2\tau_2$, and also phase shifted by 180°. The magnitude of the resultant signal will depend on the carrier frequency, with the maximum amplitude occurring when the delay $2\tau_2$ produces a phase shift of 180°, such that when combined with the phase shift through the weight a total phase shift of 360° is obtained giving constructive interference. Constructive interference occurs when the phase difference is 0° or a multiple number of whole wavelengths. This requires a separation distance of $d= \frac{\lambda}{4}$. Hence optimum transmission in the desired direction will be obtained with separation of $d=\frac{\lambda}{4}$, but useful performance will still be obtainable with other separations, except in the extreme case with zero separation.

[0035] Figure 5 shows the arrangement of figure 3, further modified so that it is possible to monitor the success of the cancellation process.

[0036] Sensing coils 600, 610, 620 are arranged, one per phase line, to detect signals present on the busbar. The sensing should preferably be by an inductive coil which is wound around the busbar, or laid closely adjacent to it. Sensing is also possible by a capacitive link or by one or more antennas located close to the busbars.

[0037] Each sensing coil is coupled to a switch 630 and a weight calculation unit 640. The weight calculation unit outputs control signals to each of the weights, W_B, W_R, W_Y. Switch 630 allows a single calculation unit to be time-shared among the monitoring signals. Calculation unit 640 operates to apply weight values which minimise the level of the monitoring signal detected by the sensing coils. An attenuated signal is adequate for monitoring, and this allows weakly coupled inductive coils to be used.

[0038] While it is preferable to sense at the unscreened section of the network where radiation is likely to occur, it is also possible to sense at another point nearer position X, or even at position X itself. However, because cable 120 is reasonably well screened, another form of sensing device would be needed, such as a capacitive link.

[0039] The operation of the weight calculation unit 640 will now be described. There are two main methods of calculating weight values; by perturbation and by a correlation technique.

[0040] Figure 6 shows a weight cancelling unit which performs the perturbation technique. A monitoring signal is applied to a channel filter 700, which passes only those frequencies which are of interest (the RF frequencies which are to be cancelled). A power detector 710, shown simply as a diode detector D and capacitor C, provide a power measurement which is applied to an analogue to digital converter 720. The output of the A-D converter is fed to a microprocessor 730 which performs a perturbation algorithm. The microprocessor outputs a set of weight control signals which control the in-phase (I) and quadrature (Q) elements of each weight. The perturbation process works by applying steps in the size of I and Q weight values and monitoring how that affects the cancellation. The algorithm can work by successively changing I up, I down; Q up, Q down. After these four steps have been performed the change in I or Q which had the best effect is adopted. This process continues until the best cancellation effect is achieved.

[0041] The second technique for calculating weight values is by correlation. This is shown in figure 7. As with the perturbation technique, an input from the sensing coils is applied to a filter, which passes only the band of RF frequencies which are of interest. The filtered signal is split, by a coupler 740 into in-phase (I) and quadrature (Q) components. This forms the sum component (S). A portion of the input signal from the basestation BS is split by splitter 780 and fed into a second coupler 750 which also splits the signal into I and Q components. This forms the element component (E). The two sets of I and Q components are fed to a correlator 760. A-D converters operate on each of the four inputs to the device. The correlator performs a correlation of the E and S components and outputs the result to a microprocessor 770 which performs a weight update algorithm. A typical algorithm is:

$$W_{(K+1)} = W_{K-\mu} E * S$$

where E * S is the correlation function.

[0042] Microprocessor 770 outputs a set of control signals to control the value of the weights. This technique, similarly to the perturbation technique, is iterative, and is repeated until the best cancellation is achieved.

[0043] Once the weight values have been set, the weight calculation process should only need to be repeated periodically.

[0044] Cancellation is most effective at the carrier frequency where the main and auxiliary signals are exactly in anti-phase. Moving each side of this frequency the cancellation effect will be decreasingly less effective. This is due to imperfections in the tracking over frequency between the phase and amplitude responses of the main and auxiliary channels and due to mismatch in the delay. Preferably the centre frequency of the band is chosen as the frequency where cancellation is most effective, e.g. 4MHz for the band 2-6MHz. This scheme is therefore most effective with TDMA systems such as DECT, which employ a limited number of time-shared carriers. A broader band cancellation is possible by modifying the arrangement as shown in figure 8.

[0045] In figure 8, the signals in the auxiliary path are split into several portions, which are each delayed by differing amounts and separately weighted before recombination. The weights are under the under control of the adaptive loop, and adapted in turn in a time-shared manner.

[0046] It is proposed to use time division multiple access (TDMA) or time division duplex (TDD) transmission schemes such as DECT or CT2. This is because these schemes use a single carrier for transmission in both the upstream and downstream directions. This simplifies filtering equipment which is needed at the subscriber premises. It is the downstream transmissions from the basestation to subscriber premises which causes radiation problems because high power RF signals are injected near to the substation. Upstream transmission from subscribers to the basestation arrive at the basestation at low levels which should not cause radiation problems. The subscribers located nearest to the basestation are controlled such that their transceivers transmit at a lower level compared with other transceivers located further from the base station.

[0047] Cancellation is operable during the period when the base station is transmitting downstream. During the basestation receive period, when subscribers

transmit upstream, the auxiliary path is not used and the basestation receives only via the main path.

[0048] Alternatively, the auxiliary path can be utilised in addition to the main path during the receive cycle. In this case, the auxiliary path needs to establish the same amplitude and phase response in both receive and transmit directions.

[0049] The effect will be to prevent reception of signals from the direction of the bus bars, and to preferentially receive signals originating from the subscriber on cable 120.

[0050] Transmitting telecommunications signals in one direction along a power line has two main applications. Firstly, by transmitting only in a direction away from the substation radiation from the substation is minimised. Secondly, by transmitting only in a direction away from the substation, it is possible to reuse the same band of frequencies on several power lines. Figure 9 shows an electricity distribution network with a substation 100 which serves three distribution cables 120, 130, 140. Each distribution cable is served by a respective communications base station BS1, BS2, BS3. The common coupling of cables 120, 130, 140 at substation 100 means that telecommunications signals from one line, eg line 120, will flow onto the other lines 130, 140. Coupling telecommunications signals onto each line so that they propagate away from the substation, and have a negligible component in the direction towards the substation, allows the same frequency band to be used by each base station BS1, BS2, BS3. Frequency reuse may be desirable where traffic demand from the subscribers on each line requires a base station to serve just that line, but there is only a limited band of frequencies available for power line communication. The limit on the band of frequencies for power line communications may be due to government regulations or because it is found that a particular band of frequencies offers optimum performance.

[0051] In figure 9 signals V_1, V_2, V_3 represent the directional transmissions from base stations BS1, BS2, BS3 which can each share a common frequency band.

Claims

1. Apparatus for coupling signals to a line, the apparatus comprising:

- an input (110) for receiving a wanted signal;
- a first means (200) for coupling the wanted signal onto the line at a first position;
- a cancelling means (W), coupled to the input, for deriving a cancelling signal from the wanted signal, the cancelling means being operable to phase-shift the wanted signal;
- a second means (300) for coupling the cancelling signal onto the line at a second position, spaced from the first position; and wherein the apparatus is arranged so that the combination of the phase-shift and propagation delays experienced by the signals causes the wanted signal and the cancelling signal to destructively combine in a single direction of propagation along the line while enabling the wanted signal to propagate in the other direction along the line.

2. Apparatus according to claim 1 wherein the cancelling means (W) is operable to scale the wanted signal in amplitude.

3. Apparatus according to claims 1 or 2 wherein the spacing of the first and second couplers is substantially one quarter of a wavelength of the wanted signal.

4. Apparatus according to any one of claims 1 to 3 further comprising a monitor (600; 610; 620) for sensing the combination of the wanted and cancelling signals at a position on the line and feeding the sensed signal to a calculating means (640) which controls the cancelling means (W).

5. Apparatus according to claim 4 wherein the cancelling means (W) comprises a weight (W_Y; W_R; W_B) and the calculating means (640) performs an iterative technique in which perturbations are applied to the value of the weight and the sensed signal is monitored to determine the effect of the perturbations.

6. Apparatus according to claim 5 wherein the calculating means (640) performs an iterative technique in which the sensed signal is correlated with a portion of the wanted signal to determine updated weight values.

7. Apparatus according to any one of the preceding claims wherein the line comprises a power line and the wanted signal comprises a telecommunications signal (V_B).

8. An electricity distribution network for serving a plurality of subscribers, the network incorporating an apparatus according to any one of the preceding claims, and wherein the wanted signal comprises a telecommunications signal (V_B) which is coupled onto a distribution line (120) of the network.

9. An electricity distribution network according to claim 8 wherein the telecommunications signal (V_B) is coupled onto the network at a position between an unshielded part of the network and the subscribers.

10. An electricity distribution network according to claim 8 or claim 9 wherein the distribution cable (120)

comprises a plurality of phase lines, and wherein the apparatus for coupling signals is coupled to one of the phase lines.

11. An electricity distribution network according to claim 8 or claim 9 wherein the distribution cable (120) comprises a plurality of phase lines, and wherein there is one apparatus for coupling signals coupled to each one of the phase lines, there also being a monitor (600; 610; 620) for sensing the combination of the wanted and cancelling signals at a position on each of the phase lines and a single calculating means (640) which controls the cancelling means (W), wherein there is a switch (630) which is operable to selectively connect the sensed signal from one of the monitors (600; 610; 620) to the calculating means (640).

12. A method of coupling signals to a line, the method comprising:

- receiving a wanted signal at an input (110);
- coupling the wanted signal onto the line at a first position;
- deriving, at a cancelling means (W), which is coupled to the input (110), a cancelling signal from the wanted signal, the cancelling means (W) being operable to phase-shift the wanted signal;
- coupling the cancelling signal onto the line at a second position, spaced from the first position;

and wherein the combination of the phase-shift and propagation delays experienced by the signals is arranged such that the wanted signal and the cancelling signal destructively combine in a single direction of propagation along the line while enabling propagation of the wanted signal along the line in the other direction.

13. A method according to claim 12 wherein the line comprises a power line and the wanted signal comprises a telecommunications signal (V_B).

14. A method of coupling communications signals on to an electricity distribution network comprising a substation (100) serving a plurality of distribution lines (120), the method comprising:

- coupling communications signals occupying a frequency band to one of the lines by coupling a wanted communications signal onto the line at a first position and coupling a cancelling signal onto a line at a second position, spaced from the first position such that the wanted communications signal and cancelling signal destructively combine in a direction of propagation towards the substation; and,
- reusing the frequency band for coupling different communications signals on to another one of the plurality of lines.

Patentansprüche

1. Vorrichtung zum Koppeln von Signalen auf eine Leitung, wobei die Vorrichtung folgendes umfasst:

- einen Eingang (110) zum Empfang eines Nutzsignals,
- eine erste Einrichtung (200) zum Koppeln des Nutzsignals auf die Leitung an einer ersten Position,
- eine Unterdrückungseinrichtung (W), die mit dem Eingang gekoppelt ist, um ein Unterdrükkungssignal aus dem Nutzsignal abzuleiten, wobei die Unterdrückungseinrichtung betreibbar ist, um das Nutzsignal in der Phase zu verschieben,
- eine zweite Einrichtung (300) zum Koppeln des Unterdrückungssignals auf die Leitung an einer zweiten Position, die einen Abstand von der ersten Position aufweist,

wobei die Vorrichtung so ausgebildet ist, dass die Kombination der Phasenverschiebung und der Ausbreitungsverzögerungen, die auf die Signale einwirken, eine destruktive Kombination des Nutzsignals und des Unterdrückungssignals in einer einzigen Ausbreitungsrichtung entlang der Leitung hervorrufen, während eine Ausbreitung des Nutzsignals in der anderen Richtung entlang der Leitung ermöglicht wird.

2. Vorrichtung nach Anspruch 1, bei der die Unterdrückungseinrichtung (W) betreibbar ist, um die Amplitude des Nutzsignals zu skalieren.

3. Vorrichtung nach Anspruch 1 oder 2, bei der der Abstand der ersten und zweiten Koppler im wesentlichen eine Viertelwellenlänge des Nutzsignals ist.

4. Vorrichtung nach einem der Ansprüche 1 bis 3, die weiterhin eine Überwachungseinrichtung (600; 610; 620) zur Messung der Kombination der Nutz- und Unterdrückungssignale an einer Position auf der Leitung und zur Zuführung des gemessenen Signals an eine Recheneinrichtung (640) umfasst, die die Unterdrückungseinrichtung (W) steuert.

5. Vorrichtung nach Anspruch 4, bei der die Unterdrückungseinrichtung (W) eine Bewertung (W_Y; W_R; W_B) bildet, und die Recheneinrichtung (640) eine iterative Technik ausführt, bei der Perturbationen auf den Wert der Bewertung angewandt werden, wobei das gemessene Signal überwacht wird, um

die Wirkung der Perturbationen zu bestimmen.

6. Vorrichtung nach Anspruch 5, bei der die Recheneinrichtung (640) eine iterative Technik ausführt, bei der das gemessene Signal mit einem Teil des Nutzsignals korreliert wird, um aktualisierte Bewertungs-Werte zu bestimmen.

7. Vorrichtung nach einem der vorhergehenden Ansprüche, bei der die Leitung durch eine Stromnetzleitung gebildet ist, und bei der das Nutzsignal durch ein Telekommunikationssignal (V_B) gebildet ist.

8. Elektrizitäts-Verteilungsnetz zur Versorgung einer Vielzahl von Teilnehmern, wobei das Netz eine Vorrichtung nach einem der vorhergehenden Ansprüche beinhaltet, und bei dem das Nutzsignal durch ein Telekommunikationssignal (V_B) gebildet ist, das auf eine Verteilungsleitung (120) des Netzes gekoppelt ist.

9. Elektrizitäts-Verteilungsnetz nach Anspruch 8, bei dem das Telekommunikationssignal (V_B) auf das Netz an einer Position zwischen einem nicht-abgeschirmten Teil des Netzes und den Teilnehmern gekoppelt ist.

10. Elektrizitätsverteilungsnetz nach Anspruch 8 oder 9, bei dem das Verteilungskabel (120) eine Mehrzahl von Phasenleitungen umfasst, und bei dem die Vorrichtung zum Koppeln von Signalen mit einer der Phasenleitungen gekoppelt ist.

11. Elektrizitätsverteilungsnetz nach Anspruch 8 oder 9, bei dem das Verteilungskabel (120) eine Mehrzahl von Phasenleitungen umfasst, und bei dem eine Vorrichtung zum Koppeln von Signalen mit jeder einzelnen der Phasenleitungen gekoppelt ist, wobei weiterhin eine Überwachungseinrichtung (600; 610; 620) zur Messung der Kombination der Nutz- und Unterdrückungssignale an einer Position auf jeder der Phasenleitungen und eine einzige Recheneinrichtung (640) vorgesehen ist, die die Unterdrückungseinrichtung (W) steuert, wobei ein Schalter (630) vorgesehen ist, der so betreibbar ist, dass er selektiv das gemessene Signal von einer der Überwachungseinrichtungen (600; 610; 620) mit der Recheneinrichtung (640) verbindet.

12. Verfahren zum Koppeln von Signalen mit einer Leitung, wobei das Verfahren folgendes umfasst:

- Empfangen eines Nutzsignals an einem Eingang (110),
- Koppeln des Nutzsignals auf die Leitung an einer ersten Position,
- Ableiten eines Unterdrückungssignals von dem Nutzsignal an einer Unterdrückungseinrichtung (W), die mit dem Eingang (110) gekoppelt ist, wobei die Unterdrückungseinrichtung (W) zur Phasenverschiebung des Nutzsignals betreibbar ist,
- Koppeln des Unterdrückungssignals auf die Leitung an einer zweiten Position, die einen Abstand von der ersten Position aufweist,

wobei die Kombination der Phasenverschiebung und der Ausbreitungsverzögerungen, die auf die Signale einwirkt derart ausgebildet ist, dass das Nutzsignal und das Unterdrückungssignal sich destruktiv in einer einzigen Ausbreitungsrichtung entlang der Leitung kombinieren, während eine Ausbreitung des Nutzsignals entlang der Leitung in der anderen Richtung ermöglicht wird.

13. Verfahren nach Anspruch 12, bei dem die Leitung durch eine Stromnetzleitung gebildet ist, und bei dem das Nutzsignal durch ein Telekommunikationssignal V_B gebildet ist.

14. Verfahren zum Koppeln von Kommunikationssignalen auf ein Elektrizitäts-Verteilungsnetz, das eine Unterstation (100) aufweist, die eine Vielzahl von Verteilungsleitungen (120) bedient, wobei das Verfahren folgendes umfasst:

- Koppeln von Kommunikationssignalen, die ein Frequenzband belegen, mit einer der Leitungen durch Koppeln eines Nutzkommunikationssignals auf die Leitung an einer ersten Position und durch Koppeln eines Unterdrükkungssignals auf eine Leitung an einer zweiten Position, die einen Abstand von der ersten Position derart aufweist, dass sich eine destruktive Kombination des Nutz-Kommunikationssignals und des Unterdrükkungssignals in einer Ausbreitungsrichtung in Richtung auf die Unterstation ergibt, und
- erneutes Verwenden des Frequenzbandes zum Koppeln unterschiedlicher Kommunikationssignale an eine andere der Mehrzahl der Leitungen.

Revendications

1. Dispositif pour coupler des signaux sur une ligne, le dispositif comportant :

- une entrée (110) pour recevoir un signal voulu,
- des premiers moyens (200) pour coupler le signal voulu sur la ligne à une première position,
- des moyens d'annulation (W), couplés à l'entrée, pour dériver un signal d'annulation à partir du signal voulu, les moyens d'annulation étant

opérationnels pour déphaser le signal voulu,
- des seconds moyens (300) pour coupler le signal d'annulation sur la ligne à une seconde position, espacée de la première position,

et dans lequel le dispositif est conçu de sorte que la combinaison du déphasage et des retards de propagation subis par les signaux amène le signal voulu et le signal d'annulation à se combiner de manière destructrice dans une direction unique de propagation le long de la ligne tout en permettant au signal voulu de se propager dans l'autre direction le long de la ligne.

2. Dispositif selon la revendication 1, dans lequel les moyens d'annulation (W) sont opérationnels pour mettre à l'échelle le signal voulu en termes d'amplitude.

3. Dispositif selon la revendication 1 ou 2, dans lequel l'espacement des premier et second coupleurs est pratiquement égal à un quart d'une longueur d'onde du signal voulu.

4. Dispositif selon l'une quelconque des revendications 1 à 3, comportant de plus un dispositif de surveillance (600 ; 610 ; 620) pour détecter la combinaison des signaux voulu et d'annulation à une position sur la ligne et alimenter le signal détecté dans des moyens de calcul (640) qui commandent les moyens d'annulation (W).

5. Dispositif selon la revendication 4, dans lequel les moyens d'annulation (W) comportent un poids (W_Y ; W_R ; W_B) et les moyens de calcul (640) effectuent une technique itérative dans laquelle des perturbations sont appliquées à la valeur du poids et le signal détecté est surveillé pour déterminer l'effet des perturbations.

6. Dispositif selon la revendication 5, dans lequel les moyens de calcul (640) effectuent une technique itérative dans laquelle le signal détecté est corrélé à une partie du signal voulu pour déterminer des valeurs de poids mises à jour.

7. Dispositif selon l'une quelconque des revendications précédentes, dans lequel la ligne comporte une ligne de puissance et le signal voulu comporte un signal de télécommunications (V_B).

8. Réseau de distribution d'électricité pour desservir une pluralité d'abonnés, le réseau comportant un dispositif selon l'une quelconque des revendications précédentes, et dans lequel le signal voulu comporte un signal de télécommunications (V_B) qui est couplé sur une ligne de distribution (120) du réseau.

9. Réseau de distribution d'électricité selon la revendication 8, dans lequel le signal de télécommunications (V_B) est couplé sur le réseau à une position comprise entre une partie non-protégée du réseau et les abonnés.

10. Réseau de distribution d'électricité selon la revendication 8 ou 9, dans lequel le câble de distribution (120) comporte une pluralité de lignes de phase, et dans lequel le dispositif pour coupler des signaux est couplé à l'une des lignes de phase.

11. Réseau de distribution d'électricité selon la revendication 8 ou 9, dans lequel le câble de distribution (120) comporte une pluralité de lignes de phase, et dans lequel est agencé un dispositif pour coupler des signaux couplés à chaque ligne parmi les lignes de phase, sont agencés également un dispositif de surveillance (600 ; 610 ; 620) pour détecter la combinaison des signaux voulu et d'annulation à une position sur chacune des lignes de phase et des moyens de calcul uniques (640) qui commandent les moyens d'annulation (W) , dans lequel est agencé un commutateur (630) qui est opérationnel pour connecter de manière sélective le signal détecté provenant d'un des dispositifs de surveillance (600 ; 610 ; 620) aux moyens de calcul (640).

12. Procédé pour coupler des signaux sur une ligne, le procédé comportant les étapes consistant à :

- recevoir un signal voulu au niveau d'une entrée (110),
- coupler le signal voulu sur la ligne à une première position (110),
- dériver, au niveau de moyens d'annulation (W), qui sont couplés à l'entrée (110), un signal d'annulation à partir du signal voulu, les moyens d'annulation (W) étant opérationnels pour déphaser le signal voulu,
- coupler le signal d'annulation sur la ligne à une seconde position, espacée de la première position,

  et dans lequel la combinaison du déphasage et des retards de propagation subis par les signaux est conçue de sorte que le signal voulu et le signal d'annulation se combinent de manière destructrice dans une direction unique de propagation le long de la ligne tout en permettant une propagation du signal voulu le long de la ligne dans l'autre direction.

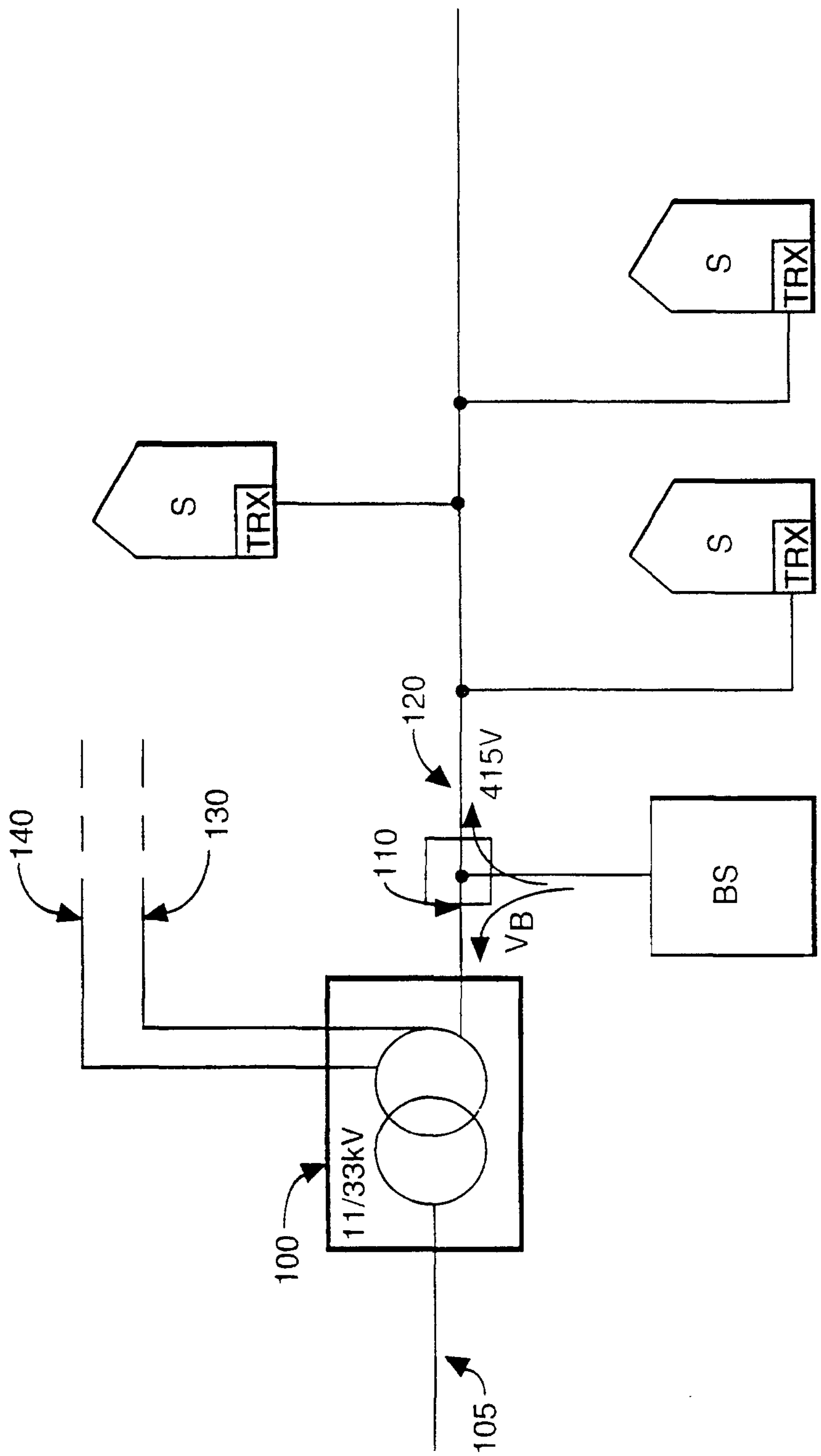
13. Procédé selon la revendication 12, dans lequel la ligne comporte une ligne de puissance et le signal voulu comporte un signal de télécommunications (V_B).

14. Procédé pour coupler des signaux de communica-

tions sur un réseau de distribution d'électricité comportant une sous-station (100) desservant une pluralité de lignes de distribution (120), le procédé comportant les étapes consistant à :

- coupler des signaux de communications occupant une bande de fréquences sur une des lignes en couplant un signal de communications voulu sur la ligne à une première position et en couplant un signal d'annulation sur une ligne à une seconde position, espacée de la première position, de sorte que le signal de communications voulu et le signal d'annulation se combinent de manière destructrice dans une direction de propagation vers la sous-station, et
- réutiliser la bande de fréquences pour coupler différents signaux de communications sur une autre ligne de la pluralité de lignes.

Fig.1.



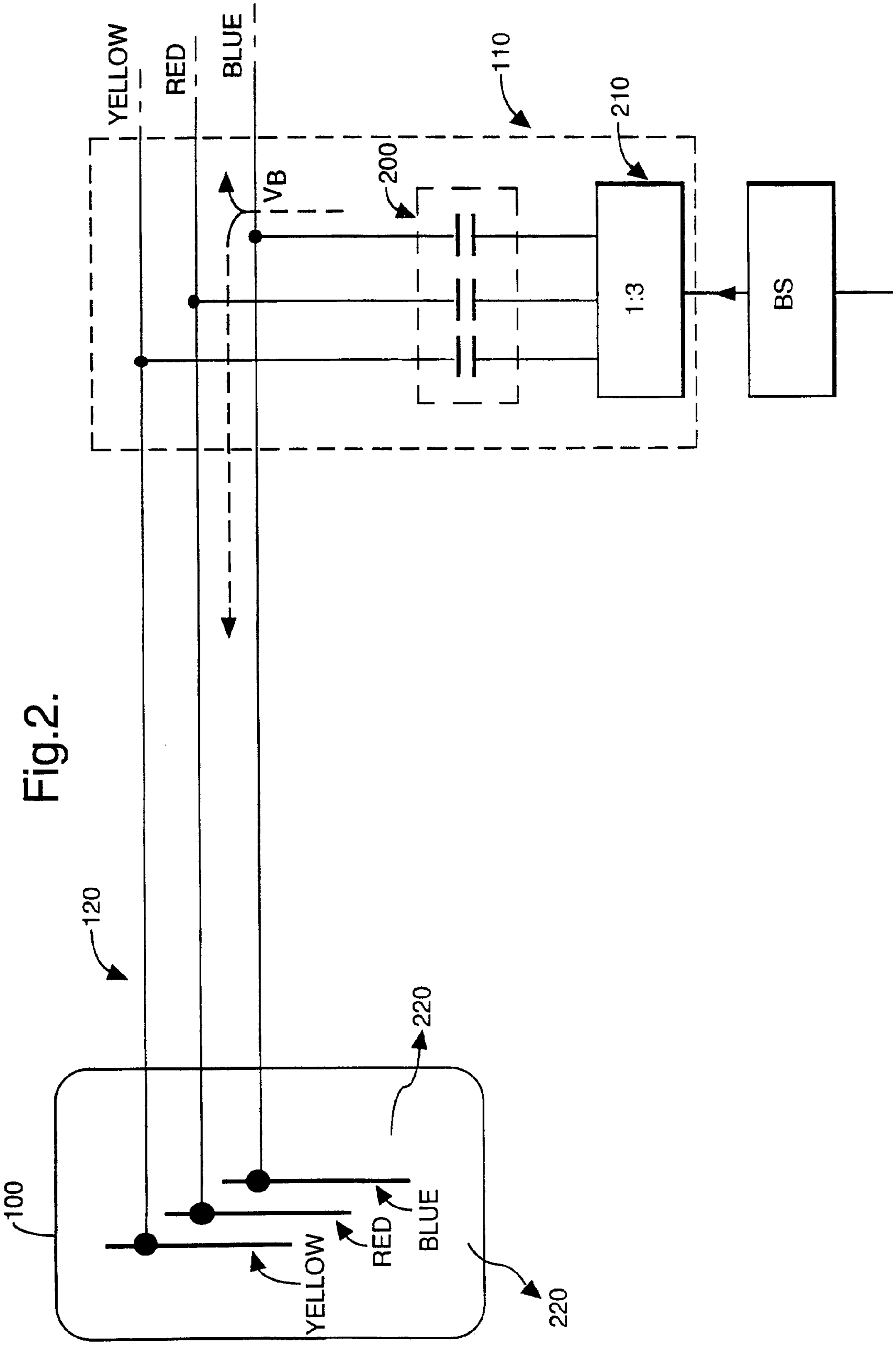

YELLOW
RED
BLUE
110
210
200
V_B
1:3
BS
120
220
100
YELLOW
RED
BLUE
220

Fig.2.

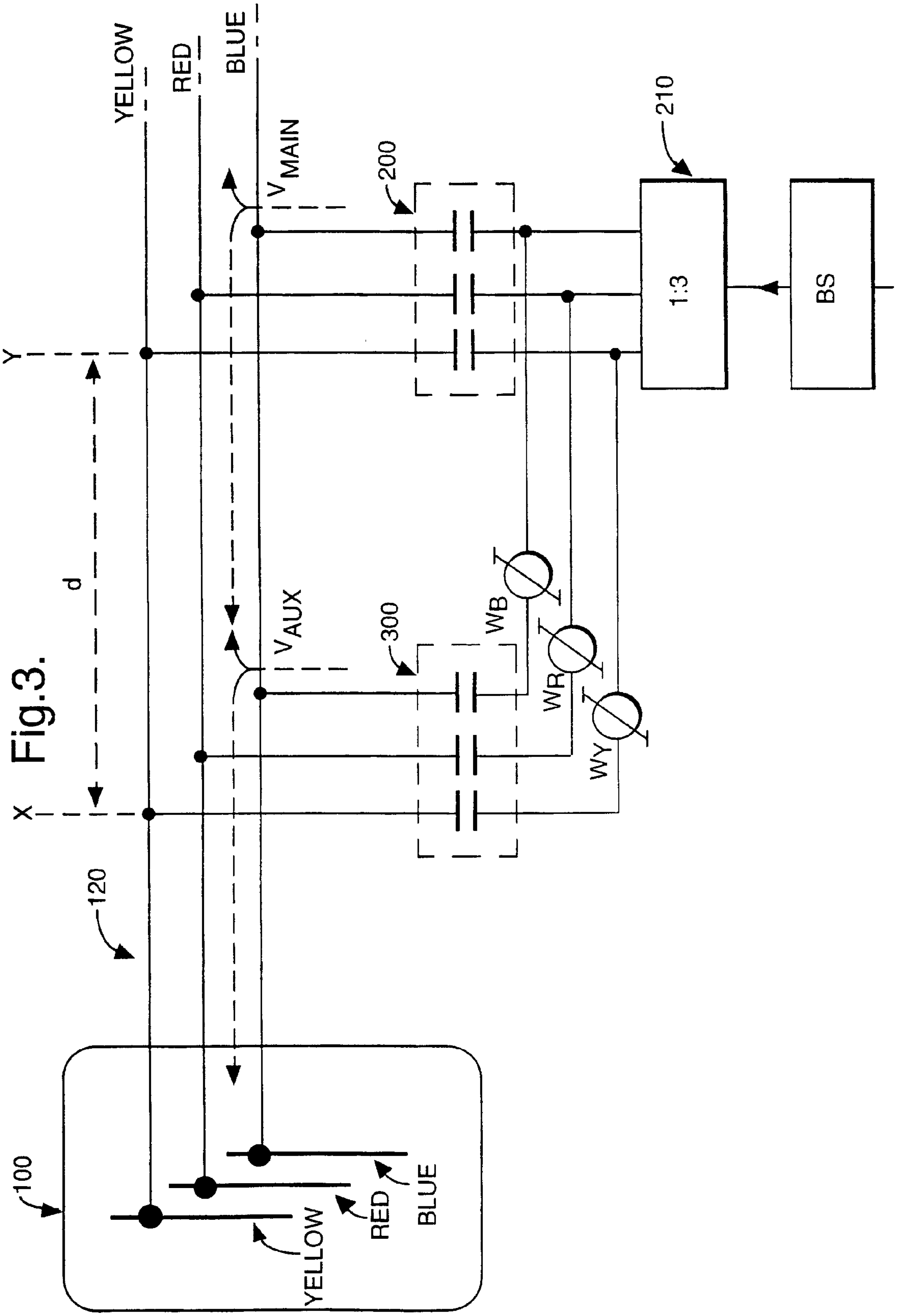

YELLOW
RED
BLUE
V MAIN
200
210
1:3
BS
Y
X
d
V AUX
300
WB
WR
WY
120
100
YELLOW
RED
BLUE

Fig.3.

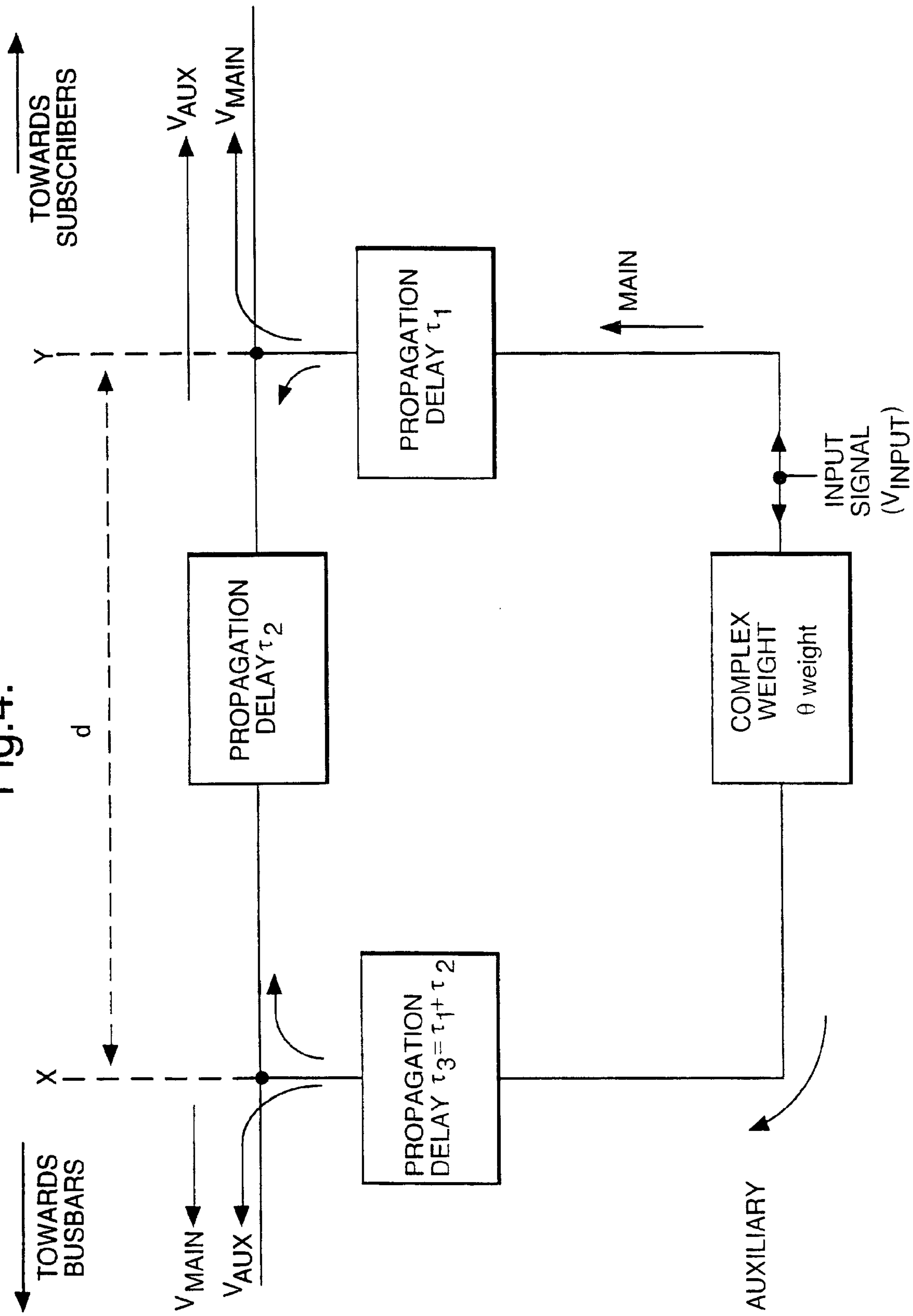

TOWARDS SUBSCRIBERS
TOWARDS BUSBARS
V_{AUX}
V_{MAIN}
Y
X
d
PROPAGATION DELAY τ_1
PROPAGATION DELAY τ_2
PROPAGATION DELAY $\tau_3 = \tau_1 + \tau_2$
MAIN
INPUT SIGNAL (V_{INPUT})
COMPLEX WEIGHT
θ weight
AUXILIARY

Fig.4.

Fig.5.

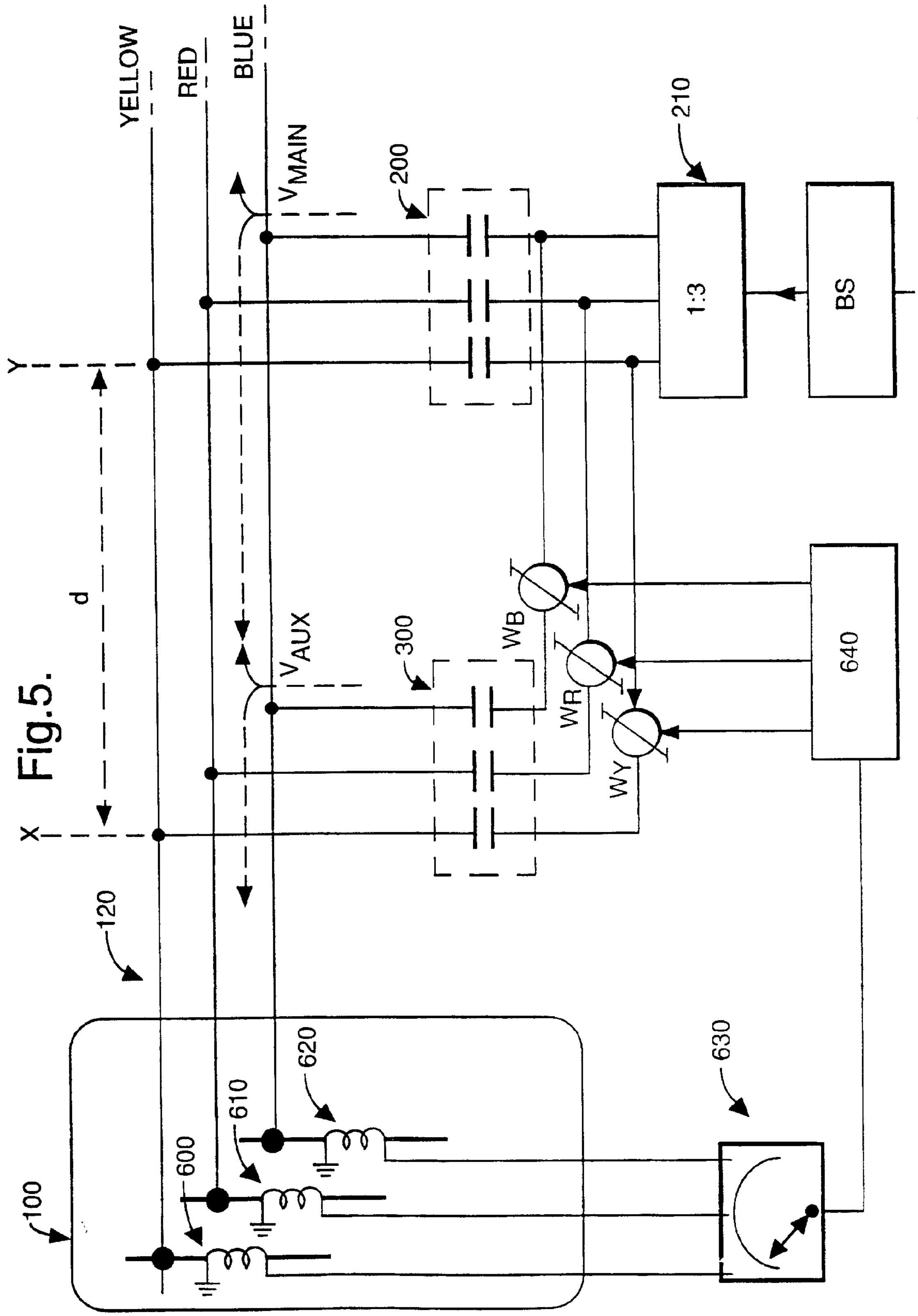

YELLOW
RED
BLUE
Y
X
d
V_{MAIN}
V_{AUX}
200
210
300
1:3
BS
640
W_B
W_R
W_Y
120
100
600
610
620
630

Fig.6.

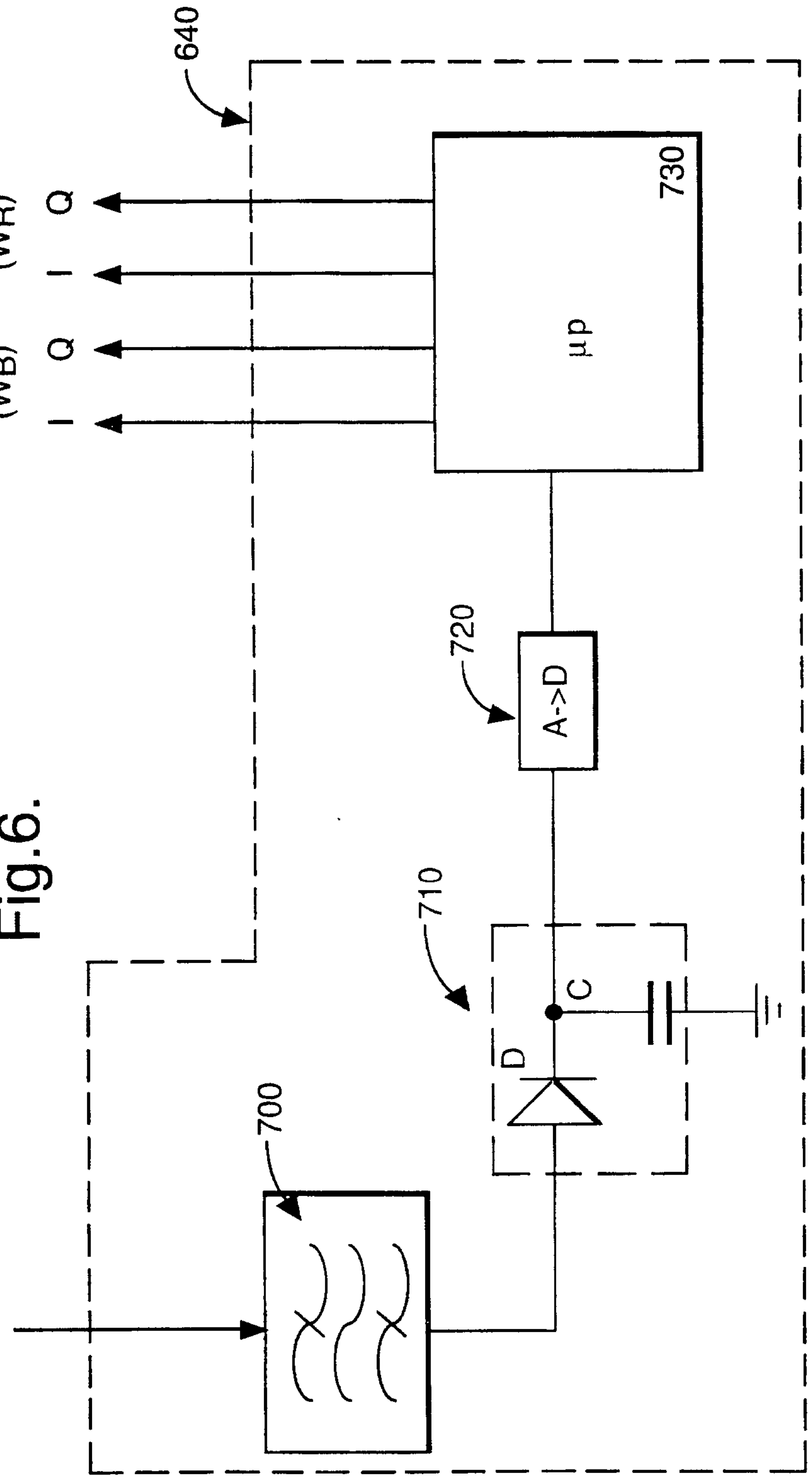


Fig.7.

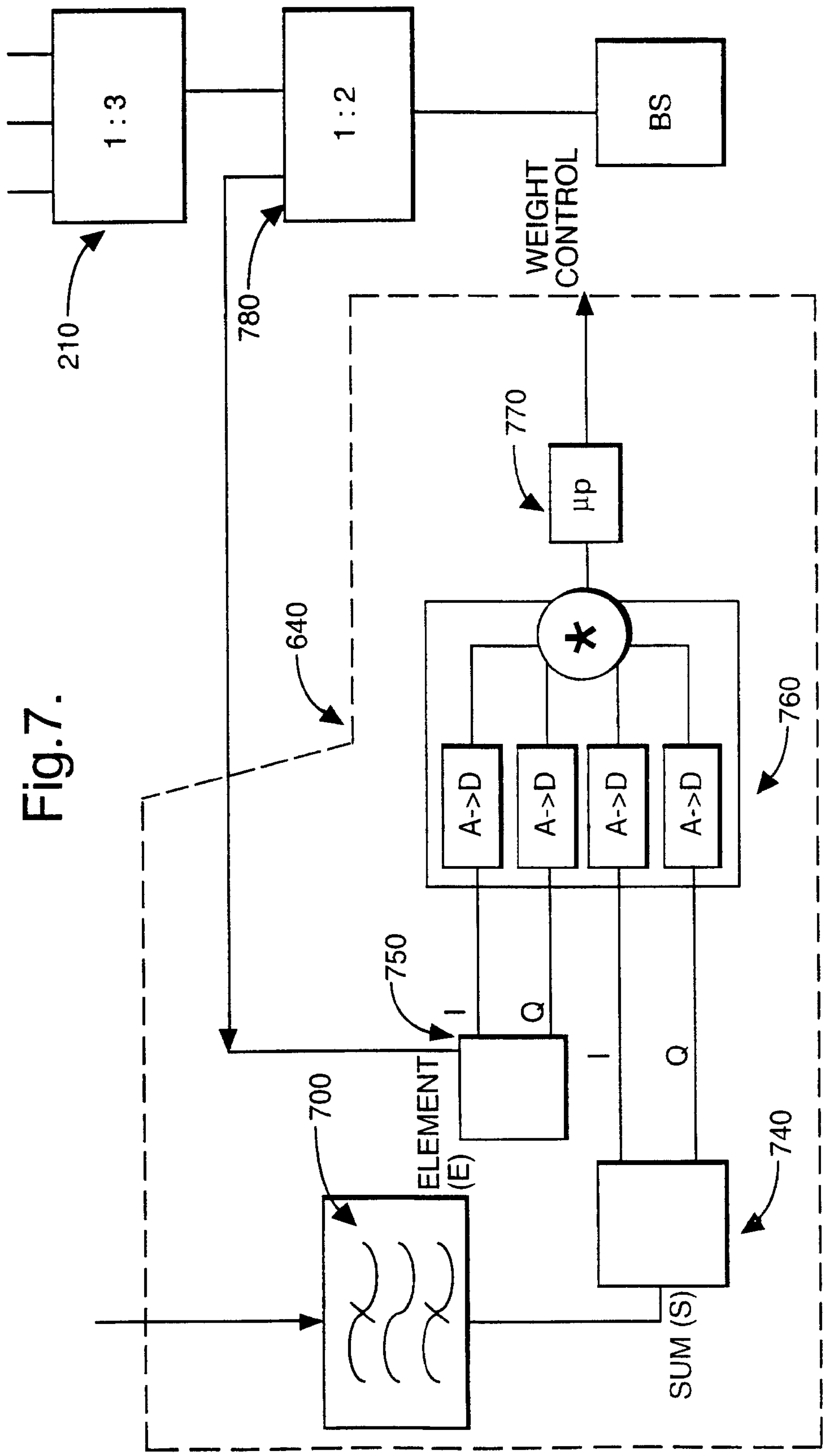
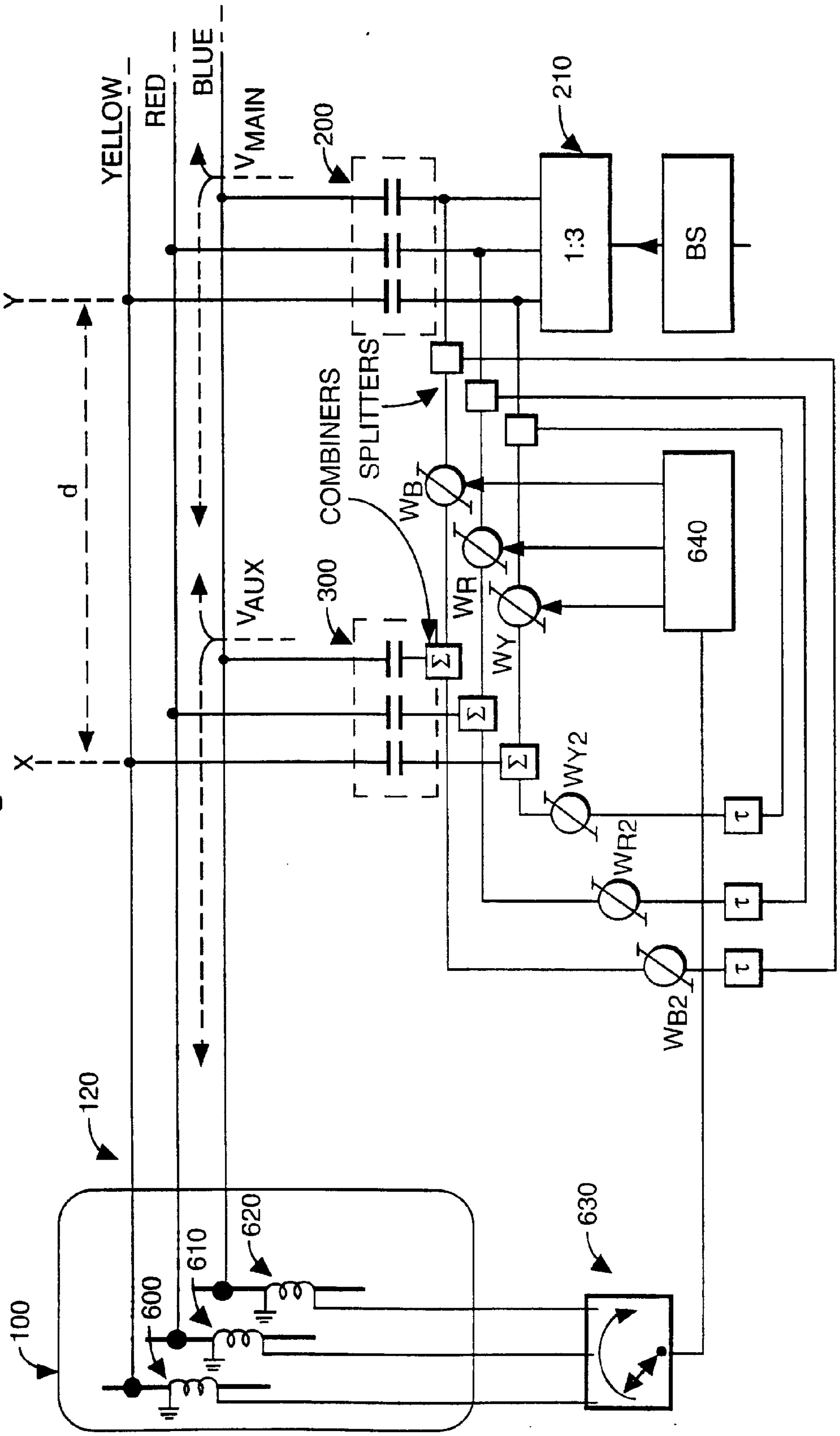

1 : 3
1 : 2
BS
210
780
WEIGHT CONTROL
770
μp
640
760
A->D
A->D
A->D
A->D
750
I
Q
I
Q
700
ELEMENT (E)
740
SUM (S)

Fig.8.


YELLOW
RED
BLUE
V_{MAIN}
V_{AUX}
Y
X
d
200
210
300
1:3
BS
640
COMBINERS
SPLITTERS
W_B
W_R
W_Y
W_{Y2}
W_{R2}
W_{B2}
Σ
τ
100
120
600
610
620
630

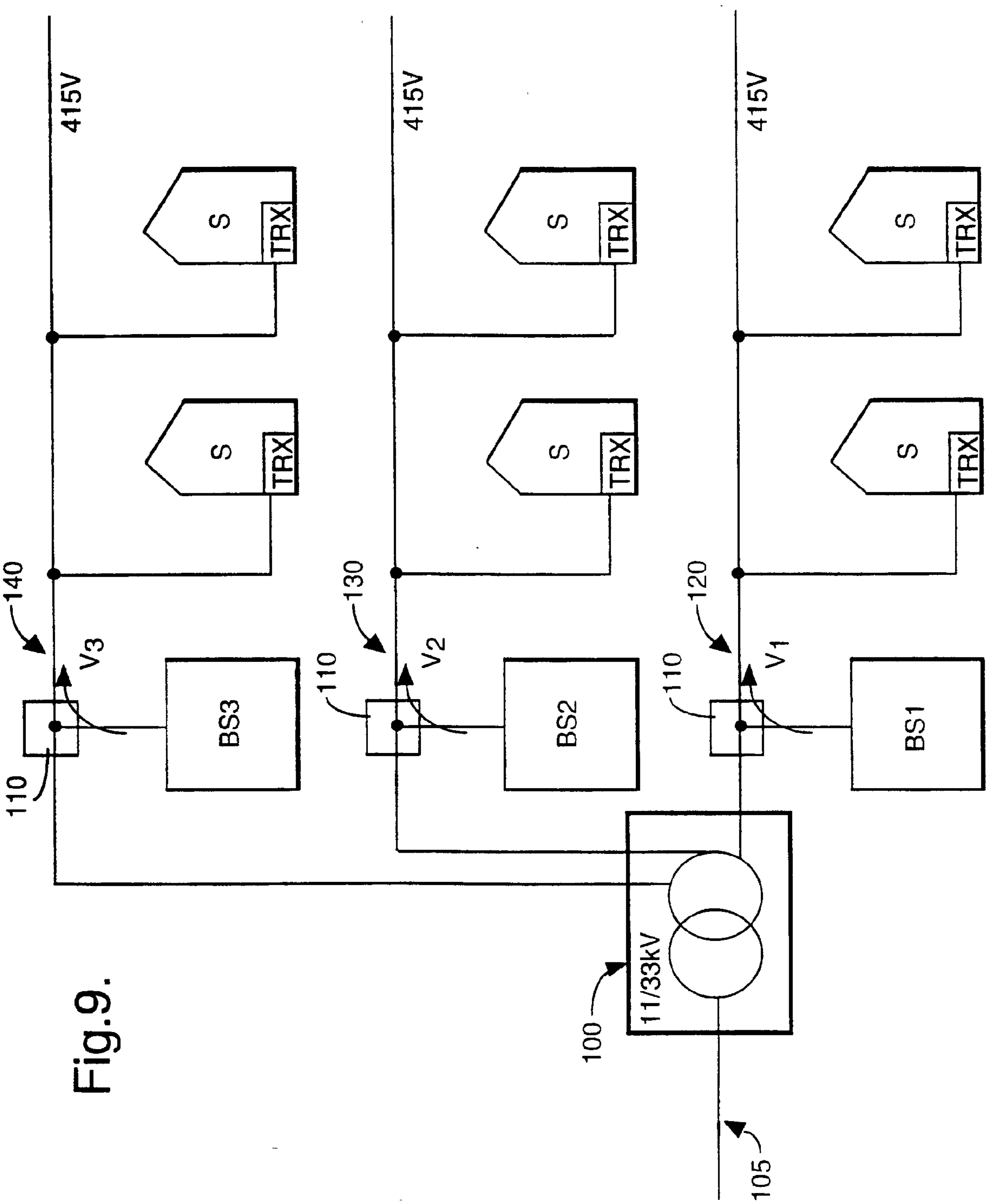

415V
415V
415V
S
TRX
BS1
BS2
BS3
140
130
120
110
V_3
V_2
V_1
100
11/33kV
105

Fig.9.